SUBSURFACE STRATIGRAPHY OF THE
STRAWN AND CANYON GROUPS OF WEST CENTRAL TEXAS,
CONCHO AND MENARD COUNTIES

A Thesis Submitted to the Faculty of
Baylor University
in Partial Fulfillment of the
Requirements for the Degree
of
Master of Science

By
Jan N. Woodard
Waco, Texas
August, 1983

ABSTRACT

Carbonate rock units of the upper Strawn Group (Desmoinesian) developed on the western flanks of the Llano uplift on a positive topographic platform, the Concho shelf. Late Mississippian and early Pennsylvanian orogenic uplifts along the Texas craton exposed the Ordovician Ellenburger Group carbonate rocks to extensive erosion and provided the paleotopographic unconformity upon which these cyclic limestones and shales were distributed.

Orogenic activity related to the advancing Ouachita Fold Belt occurred synchronously with late Strawn deposition. The rising Ouachita orogenic belt initiated a fluvial-deltaic depositional complex that prograded over a slowly subsiding carbonate shelf.

In early Canyon time (Missourian) deformation along the Ouachita Fold Belt decreased in intensity and a more stable carbonate platform environment was reestablished on the shelf.

Cycles of marine and prodeltaic shales capped by algal limestones characterize the Canyon Group. Paleotopographic variations in the lower Canyon indicate early

Missourian tectonic movement in the Ellenburger limestones. In contrast, the wedge-shape geometry of the upper Canyon carbonate units suggest shoreward-building carbonate banks. These banks developed over very porous, water-saturated prodelta shales and gained thickness as accumulating carbonates compressed the unconsolidated distal muds.

TABLE OF CONTENTS

Table of Contents Cont'd Page

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

Purpose

The upper Pennsylvanian Strawn (Desmoinesian) and Canyon (Missourian) Groups of west central Texas are important stratigraphic intervals in the production of oil and gas in Concho and Menard Counties. Although economically important in petroleum production, no comprehensive subsurface study of this interval has been pursued to date.

The purpose of this investigation is to (1) determine the subsurface geometries of the Strawn and Canyon Groups through interpretation of electric logs, (2) to relate these geometries to the ongoing depositional processes during different episodes of tectonic movement, and (3) to determine the relationship of the depositional systems to the production of oil and gas in the region.

Location

The area of this subsurface investigation is located in Concho and Menard Counties, Texas, adjacent to and northwest of the Llano uplift, between $30^{\circ}43'$N and $31^{\circ}35'$N latitude and $99^{\circ}32'$W and $100^{\circ}7'$W longitude. The study area encompasses approximately 2300 square miles, most of which has Cretaceous strata in outcrop (Fig. 1).

Method of Study

The stratigraphic interval of this investigation does not crop out in the study area. My report is based on information collected through the study and correlation of approximately 300 electric logs. Field observation of outcrops in the Colorado River and Brazos River valleys of central Texas (Fig. 2) supplemented the subsurface analysis.

Correlation of electric logs provided the necessary control in constructing structural contour maps on the top of the Ellenburger, Winchell, and Home Creek Limestones (Pls. VIII, X, XI) and a net sand map of the thick clastic sequence from the top of the Capps Limestone to the base of the Adams Branch Limestone (Pl. IX). The elevations used on the Home Creek, Winchell and Ellenburger maps are given in Appendix I.

Stratigraphic cross sections were constructed along structural strike (Pls. II, III) and structural dip (Pls. IV, V, VI, VII) in order to determine the relationship of the various units across the study area. The location of these sections can be seen on Plate I.

The general lithologic character of the units was determined primarily through extrapolation of information gathered where these units crop out to the east and northeast and by analysis of electric log characters.

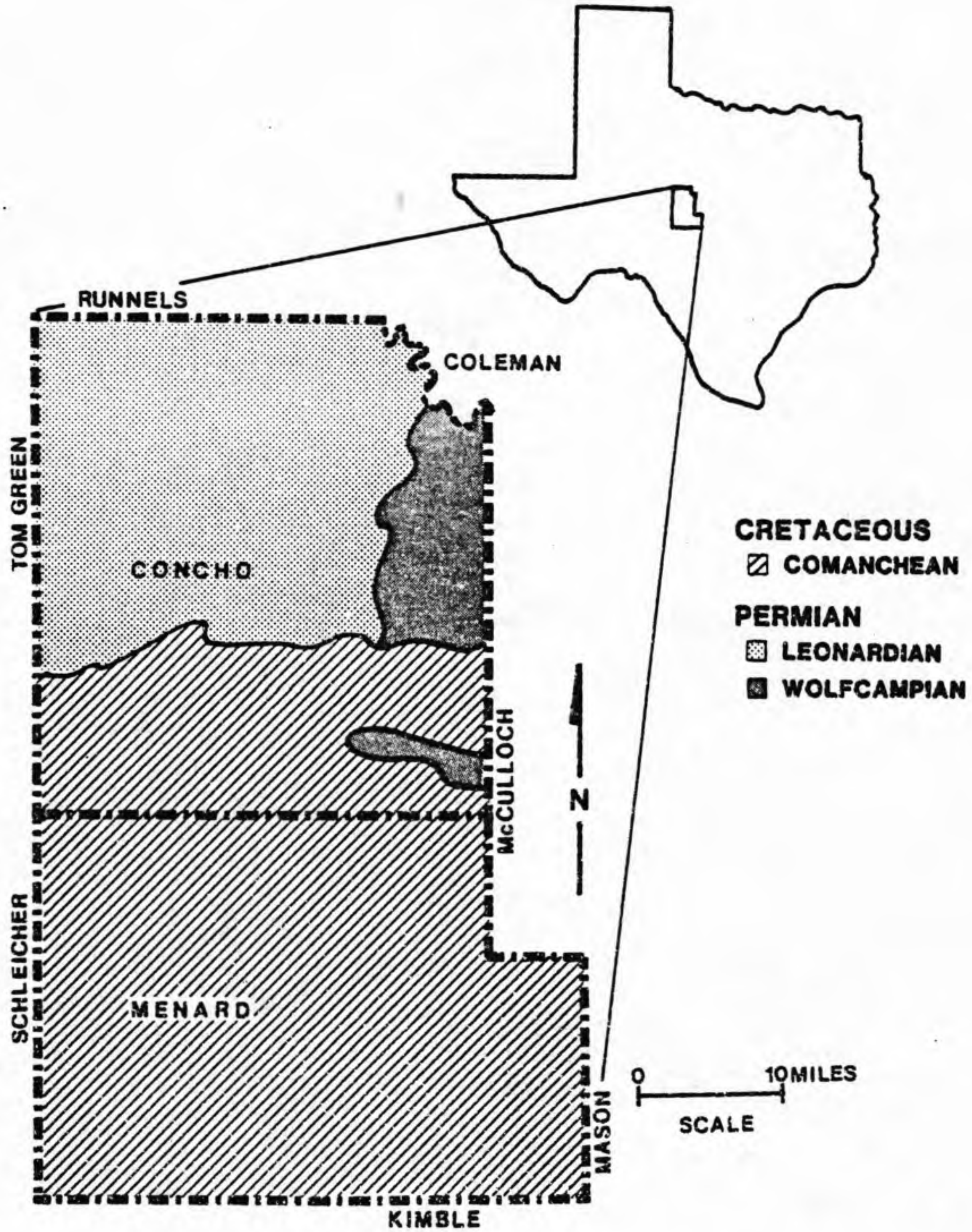

FIGURE 1. INDEX MAP TO STUDY AREA DISPLAYING PRESENT DAY SURFACE GEOLOGY

The vast majority of oil and gas wells drilled in Concho and Menard Counties are initiated by smaller, independent oil companies and as a result the availability of cores and cuttings from wells in the area was extremely limited.

In addition to structural maps and stratigraphic cross sections, a thorough research of the literature available on the area was conducted.

Previous Works

Most of the published information dealing with the Strawn and Canyon Groups in the subsurface of the study area appear in cross sections through Concho and Menard Counties. Cheney (1940) in his study of the geology of north and central Texas, constructed structural cross sections, north-south only, through the study area. Roberts (1961) made studies of the oil and gas fields of Concho and Menard Counties and their neighboring counties, and constructed cross sections through select areas. In 1962 the Abilene Geological Society also published a stratigraphic cross section (north-south) through Concho, Menard and Kimble Counties.

Adams (1951), Cheney and Gross (1952), and Flawn (1954) discuss the tectonic development of west central Texas.

Previous stratigraphic nomenclatures by various authors are discussed in subsequent sections.

Acknowledgments

The author expresses appreciation to several individuals and organizations who offered support during the course of this study. First, Bush Exploration of Midland, Texas who suggested this thesis and offered their financial support. Special thanks is given to Mark Owen and Robert Dickey whose suggestions and guidelines were very helpful.

The author also wishes to thank the thesis advisors Drs. Robert Grayson, Jr. and Don Parker for their guidance and tolerance, but mostly for their moral support. Special thanks are extended also to David Crass and Jack Trice for their invaluable assistance and constant suggestions. Special thanks are extended to Miss René Powers for her support and her preparation of the final manuscript.

Finally, the author thanks Scott Hamilton Woodard for providing the inspiration and love that supported his father throughout his studies at Baylor University.

GEOLOGIC SETTING

The study area is located in the physiographic province known as the Edwards Plateau, adjacent to and northwest of the Llano uplift (Fig. 2). In Menard County lower Cretaceous rocks (Comanchean) unconformably overlie tilted Pennsylvanian and Permian strata. To the north in Concho County this Cretaceous cover has been eroded to expose lower Permian (Wolfcampian and Leonardian) rocks that dip gently (less than 1^{o}) to the west-northwest (Fig. 1).

The nearest exposures of upper Strawn and Canyon age rocks occurs to the east of Concho County in McCulloch and Coleman Counties. They can be easily observed in a northeast trending outcrop north of the Brady Mountains (Fig. 2).

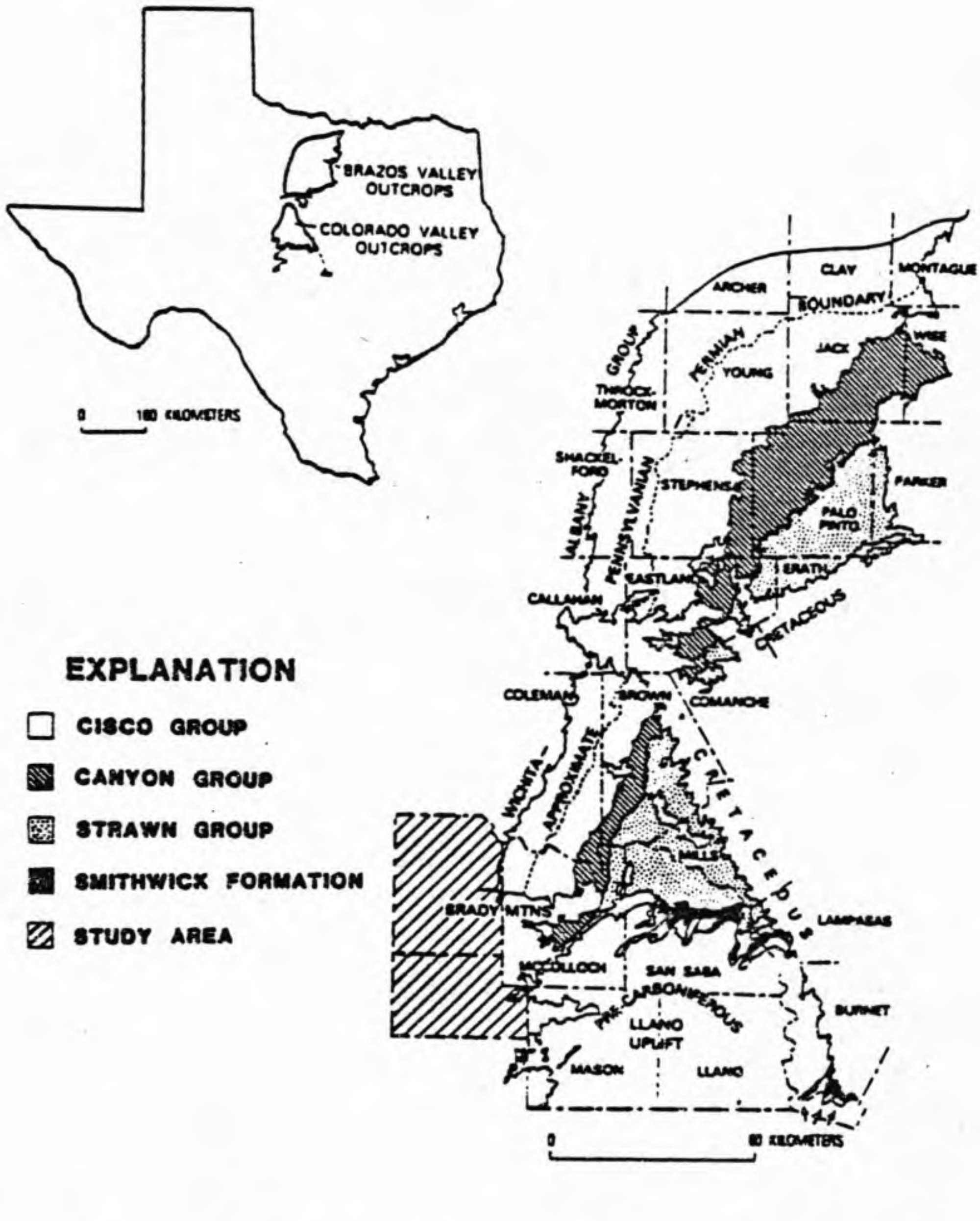

FIGURE 2. LOCATION OF OUTCROPPING PENNSYLVANIAN ROCKS IN CENTRAL TEXAS AND THEIR RELATIONSHIP TO THE STUDY AREA, adapted from Keir and others(1980)

TECTONIC SETTING

Concho and Menard Counties are located to the northwest of the Llano uplift, a Precambrian structural high (Cloud and Barnes, 1948). The uplift is an erosional remnant of a much larger Precambrian structural feature called by various authors the Concho Foreland (Cheney, 1948), the Texas Peninsula (Adams, 1951) and the Texas Craton (Flawn, 1954). This feature (Fig. 3) appears to have had a marked effect on depositional patterns from the Cambrian through the Permian.

The first Paleozoic sea to inundate west central Texas entered a region of about 800 feet maximum relief. Studies of the eolian deposited Hickory Sandstone and the overlying marine limestone of the Cap Mountain Member suggest the lower Cambrian was a period when subsidence in the region was greater than sedimentation.

Mild uplift in the middle Cambrian allowed the erosion of the lower Cambrian Lion Mountain Limestone and deposition of the Wedge Sandstone east of the study area. During this period sedimentation kept pace with subsidence and shallow water siltstones of the Point Peak were deposited. Near the end of Point Peak deposition subsidence once again exceeded sedimentation and the San Saba Member,

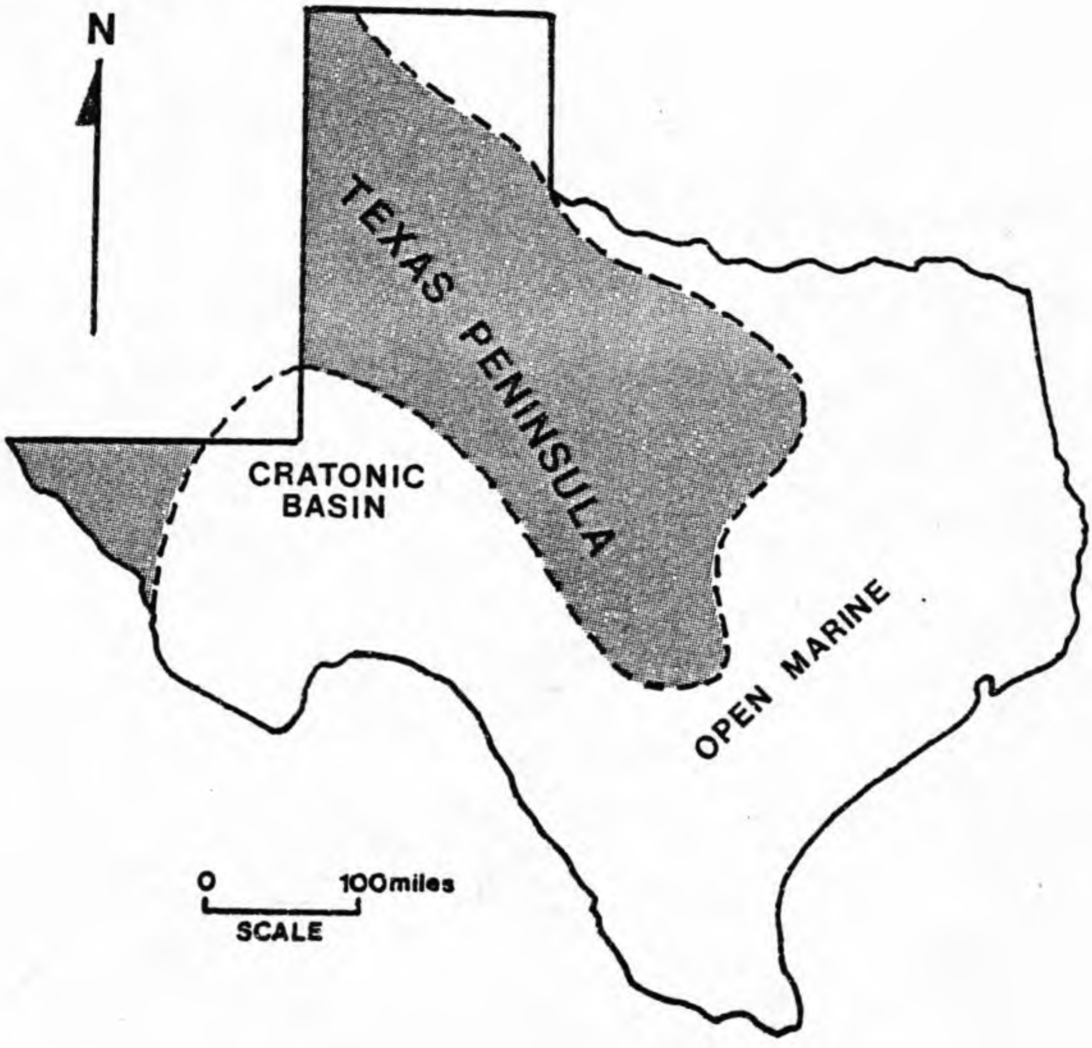

FIGURE 3. APPROXIMATE LOCATION OF THE TEXAS PENINSULA DURING ORDOVICIAN DEPOSITION, after Adams (1951)

abundant in pelmatozoan and trilobite fragments, accumulated. Reef configurations in the San Saba indicate a northeast-trending seaway that shallowed to the west and the Texas peninsula (Barnes and Bell, 1977).

Subsidence of the peninsula continued through the Cambrian as the region was slowly inundated by an extensive Ordovician epicontinental sea; evidence of which can be seen in the widespread deposition of thick limestones and dolomites of the Ellenburger Group.

In the middle to late Ordovician, uplift along the axis of the northwest-trending cratonic peninsula arched the Cambrian and early Ordovician strata forming a broad subareally exposed feature allowing extensive erosion of Cambrian and early Ordovician strata. This uplift continued into the Silurian as evidenced by the erosional thinning of the Ellenburger Group westward across west central Texas (Cheney and Gross, 1952). Rocks younger than early Ordovician and older than Mississippian were once believed to be missing from the Llano uplift of central Texas (Holmquest, 1955). Subsequent studies, however, have identified Silurian age fossils in collapse structures in older rocks in the region. The Silurian age brachiopods, found in minute erosional remnants east of the study area, indicate the region was probably covered by a shallow sea for a short period some time during the middle Silurian before being uplifted in late Silurian time (Barnes and others, 1966).

The peninsula began to subside in early Devonian time and was once again covered by an extensive epicontinental sea that deposited a thick interval of limestone and shale. Recurrent, mild regional subsidence and uplift during the Devonian is indicated by isolated outcrops of Devonian limestones resting unconformably on different members of the Ellenburger in Mason County (Barnes, Cloud, and Warren, 1947). The Devonian age sediments have been removed from the study area.

During the Mississippian the same process of mild, recurrent uplift and subsidence continued with the deposition of the Chappel Limestone and its basinward equivalent the Barnett Shale.

During the late Mississippian and early Pennsylvanian times, an elongate foreland basin (the Fort Worth basin) became defined due to structural activity in the Ouachita Fold Belt (Brown, 1973). Deposition of the Morrowan age Marble Falls Limestone is associated with the initial downwarping of the Fort Worth basin in from front of the Ouachitas and the establishment of a carbonate platform to the southwest. During the Atokan, deformation and uplift along the fold belt resulted in a northwestward shift of the axis of deposition causing a deepening of the Fort Worth basin (Flawn and others, 1961) as a westward prograding terrigenous clastic wedge (the Smithwick and lower Strawn) entered the basin along a high gradient paleoslope from the Ouachita Fold Belt (Brown, 1973). This rapid influx of clastics along the eastern flanks of the peninsula initiated the development of an asymmetrical arch along its axis. The steeper limb of the arch is to the east and the western, more gently dipping limb formed the eastern shelf of the Midland Basin. This arch, the Bend arch, proved to be a barrier in early Pennsylvanian time, restricting deposition of the Smithwick and lower Strawn to the Fort Worth basin (Brown, 1973).

As tectonic activity along the Ouachita Fold Belt increased in intensity during late Atokan and early Desmoinesian time, the now rapidly-filling Fort Worth basin could no longer accept the heavy clastic influx. Sediments derived from the system began to cross the Bend arch and were deposited on the eastern shelf of the Midland Basin (Brown, 1973).

The Electra arch of north Texas (Fig. 4) was uplifted during the early Pennsylvanian adding to the influx of clastic sediments on to the Eastern shelf (Cheney, 1940). Because of the higher sedimentation rates on the northern portion of the eastern shelf, an asymmetrical downwarping, triggered by sedimentary loading, took place resulting in a northwest-trending flexure on the southern portion of the shelf referred to in the literature as the Concho arch (Fig. 4). The flexure continued to gain prominence as

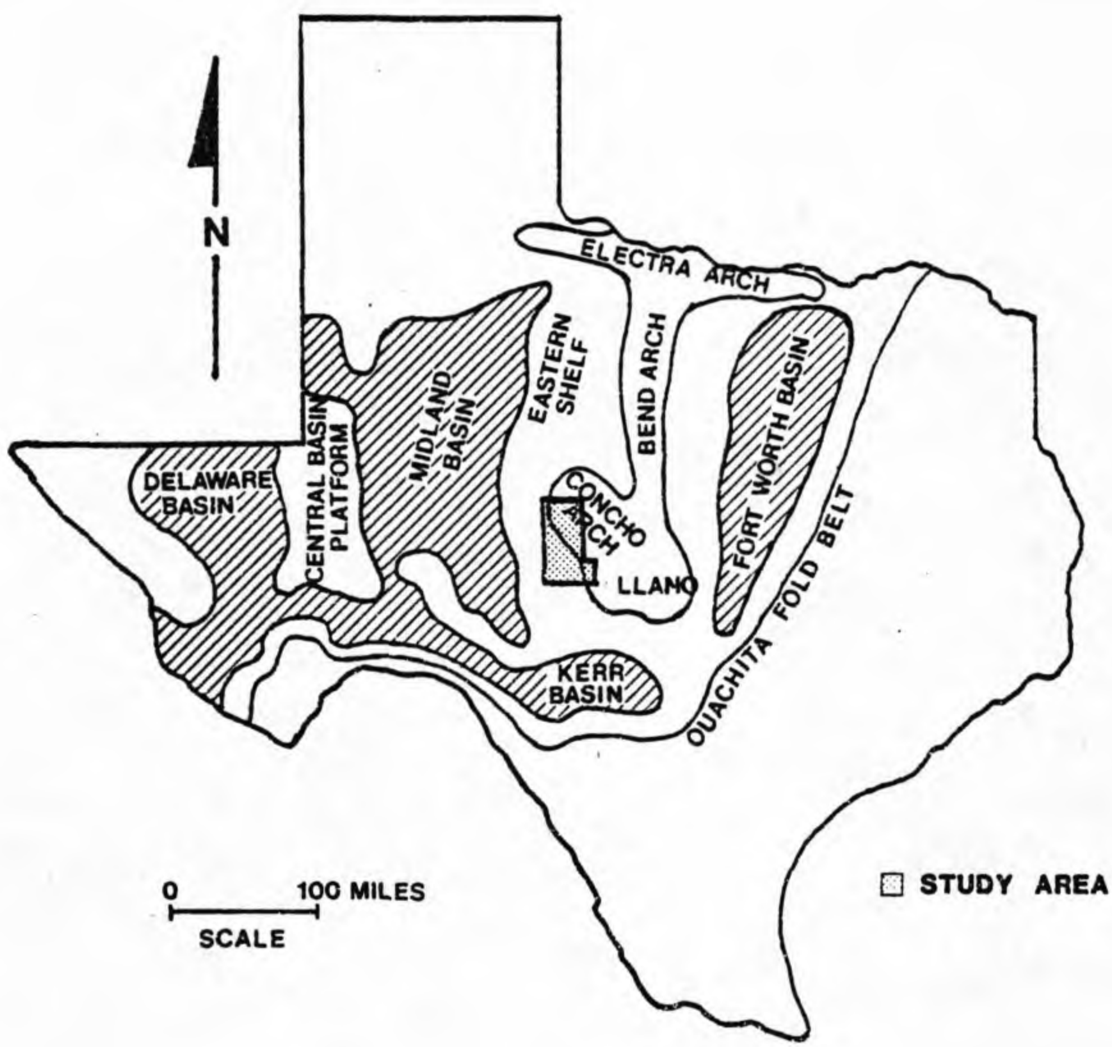

FIGURE 4. MIDDLE TO UPPER PENNSYLVANIAN GEOLOGIC SETTING

increasing amounts of clastic sediments derived from the Ouachita Fold Belt and its associated regional uplifts began to prograde on the ~~the~~ shelf from the north and east.

Late Mississippian and early Pennsylvanian uplifts along the southern portions of the peninsula had exposed the Ellenburger Group to extensive erosion south of the Concho arch. As a result, the middle to late Pennsylvanian limestones and shales of the Strawn Group were unconformably deposited on an upper Ordovician paleosurface in the study area. This is in marked contrast to the more complete stratigraphic sequence seen north of the flexure (Kier, 1972).

By the beginning of Missourian time, prior to deposition of the Canyon Group, the Concho arch was developed sufficiently to form somewhat of a barrier between the subsiding eastern shelf of the Midland basin to the north and the more stable platform to the south. Cycles of fluvial-deltaic deposition followed by limestone accumulation developed on either side of the flexure during Canyon time, but were more pronounced to the north as evidenced by thicker sequences of limestone and shales (Erxleben, 1975).

During the late Pennsylvanian, a final orogenic pulse from the Ouachita Fold Belt resulted in the deposition of the Cisco Group, another fluvial-deltaic depositional limestone bounded cyclic sequence, similar to the Canyon Group.

As sedimentary loading increased on the eastern shelf well into the Permian, beds of middle Pennsylvanian through early Permian age began to dip gently to the northwest into the subsiding Midland basin. Evidence of this tilting can

can be seen on the surface in northern Concho County where early Permian strata are exposed (Fig. 1). Structural contour maps on the Ellenburger limestones (Pl. VIII) and the top of the Canyon Group also reflect this post-depositional tilting (Pl. XI).

STRATIGRAPHIC FRAMEWORK

In the study area the upper Strawn rests unconformably on middle to upper Ordovician limestones of the Ellenburger Group. The Strawn Group (Desmoinesian and lowermost Missourian) is in turn conformably overlain by limestones and shales of the Canyon Group (Missourian).

Two approaches to the definition of the Strawn-Canyon boundary have been taken by various authors. Early writers such as Drake (1893) and Plummer and Moore (1921), placed the boundary between the two groups, on a lithostratigraphic basis, at the base of the lowermost limestone in a thick sequence of limestones, shales, and sandstones. This limestone seemed to be a natural division between the predominantly terrigenous character of the Strawn and the somewhat more marine carbonates of the Canyon, and was named the Palo Pinto Limestone in the Brazos River valley and the Adams Branch Limestone in the Colorado River valley.

Cheney (1940) in an attempt to correlate these sequences with the Carboniferous type-sections of the mid-continent used paleontological evidence, as opposed to lithostratigraphic divisions, to place the upper boundary of the Desmoinesian within the undivided sands and shales of the upper Strawn near the base of the Adams Branch.

Cheney based his Desmoinesian-Missourian boundary on the last occurrence of the brachiopod Mesolobus and the presence of the fusulinid Fusulina.

The boundary between the overlying Cisco Group (Virgilian, Wolfcampian) and the Canyon Group was found to correspond paleontologically with the earlier lithostratigraphic division placed at the top of the Home Creek Limestone.

The upper Strawn Group in Concho and Menard Counties consists of, in ascending order, the Goen Limestone, the Capps Limestone, and a thick sequence of undivided shales and sandstones, with the upper boundary being the base of the Adams Branch Limestone (Barnes, 1976).

The Canyon Group consists of a sequence of alternating limestones and shales. In ascending order these are the Adams Branch Limestone, the Cedarton Shale, the Winchell Limestone, the Placid Shale, the Ranger Limestone, the Colony Creek Shale and the Home Creek Limestone (Fig. 5).

A thick sequence of Permian strata conformably overlie the uppermost units of the Cisco Group and crop out at the surface in northern Concho County. In southern Concho County and Menard County, these Permian rocks are unconformably overlain by lower Cretaceous (Comanchean) limestones which are a part of the physiographic region known as the Edwards Plateau.

SYSTEM	SERIES	GROUP	FORMATION
PENNSYLVANIAN	MISSOURIAN	CANYON	HOME CREEK LIMESTONE
			COLONY CREEK SHALE
			RANGER LIMESTONE
			PLACID SHALE
			WINCHELL LIMESTONE
			CEDARTON SHALE
			ADAMS BRANCH LIMESTONE
		UPPER STRAWN	"CROSS CUT" SAND
	DESMOINESIAN		"WILHELM" SAND
			"MORRIS" SAND
			CAPPS LIMESTONE
			GOEN LIMESTONE
ORDOVICIAN		ELLENBURGER	ELLENBURGER LIMESTONE

FIGURE 5. STRATIGRAPHIC RELATIONSHIP OF THE STRAWN AND CANYON GROUPS

STRATIGRAPHIC NOMENCLATURE

Introduction

The nomenclature of the principle stratigraphic units in west central Texas and the Colorado River valley was set up in connection with preliminary studies by geologists primarily interested in local coal deposits. The larger divisions were first named and described by E.T. Dumble (1890) and R.S. Tarr (1890) and expounded upon by W.F. Cummuins (1891). Most of the individual beds were described by Drake (1893) in his report on the coal fields of Texas while formation names were later added by Plummer and Moore (1921) based primarily on their studies of Pennsylvanian outcrops in the Brazos River valley.

Strawn Group

Tarr (1890) first described the sandstone and shale unites that constituted the Strawn Group in the Colorado River valley as the Richland Sandstone and Milburn Shale Divisions. These beds were correlated with units in the Brazos River valley by Dumble (1890, Pl. LXIV) who referred to the sequence as the Richland-Gordon Sandstones of the Strawn Series. Cummins (1891), defined the Strawn Division in the Colorado River valley to include all the shale, sandstone, and conglomerate lying unconformably upon the Bend Division, from "Coal Seam No. 1" to the base of the overlying coral rich limestone later named the Capps.

Drake (1893) seperated the Strawn Division into 20 units of alternating sandstone and shales and numbered the units from 4 to 23, with the uppermost unit being called the Ricker Limestone. Drake's Strawn Division was stratigraphically equivalent to the Richland-Gordon Sandstone Series of Dumble (1890).

Plummer and Moore (1921) considered the Strawn Group of the Colorado River Valley to be the rocks that overlie the Smithwick Shale of the Bend Group and underlie the Rochelle Conglomerate, equivalent to their Mineral Wells and Millsap Formations in the Brazos River valley to the north. They did point out, however, that an accurate correlation of the sequence bed by bed from one valley to the other was impossible. Because the Capps Limestone overlaid the Rochelle Conglomerate, this restructuring of the nomenclature placed the Capps within the Canyon Group where it was considered part of the Brownwood Shale Mamber of the Graford Formation.

Sellards and others (1932) transferred the Capps Limestone back to the Strawn Group and considered the <u>Chaetetes</u> rich unit to be the upper member of the

Mineral Wells Formation.

Cheney (1940) proposed to drop the usage of the term "Strawn Group" and instead used the term "Strawn Series" to describe the sequence of limestones, shales and sandstones occurring above the Lampasas Series and beneath the Canyon Series. Considering the Pennsylvanian to be of systematic rank, Cheney felt the Strawn Group to be equivalent to the Desmoinesian Series of the mid-continent and therefore felt the term "Strawn Series" to be more appropriate.

Cheney (1940) and later Plummer (1950) considered the last occurrence of the brachiopod Mesolobus to be the top of the Strawn Series, placing the Strawn-Canyon boundary at the top of the Capps Limestone.

Cheney and Gross (1952) continued to use the term "Strawn Series" in their writings on the tectonics of central Texas. However, since the late 1950's the majority of the work done in the Carboniferous of west central Texas has perpetuated usage of the Strawn as a formation or a group.

For the purpose of this study the Strawn is considered a group; only the upper portion of which is present in the subsurface of the study area. The upper Strawn Group consists of, in ascending order, the Goen Limestone, the Capps Limestone, and an undivided series of sands and shales between the top of the Capps and the base of the Adams Branch Limestone (Fig. 5).

Canyon Group

Tarr (1890) recognized the sequence of rocks now assigned to the Canyon Group in the Colorado River valley as the Brownwood Division, equivalent to the Brownwood-Ranger Series which Dumble (1890, Pl. LXVii) recognized in the Brazos River valley. This sequence of limestones, sandstones, and shales was described as being above the Milburn Shales, but the upper limit was never accurately placed.

Cummins (1891) working in the Brazos River valley, recognized a thick stratigraphic interval consisting of alternating limestones and shales and assigned the name Canyon Division, for a locality in Palo Pinto County (Fig. 2). Working with the predominantly terrigenous underlying interval, Cummins projected the Strawn Division into the Colorado River valley (1981, Pl. XVI) where he placed the Strawn-Canyon contact at the base of a limestone outcropping near Brownwood, in Brown County. Cummins' cross section showed that the Brownwood Division recognized by Tarr (1890) in the Colorado River valley and his Canyon Division of the Brazos River valley were essentially the same stratigraphic interval.

Drake (1893) adopted Cummins' divisions of the rocks in the Brazos River valley, and on the basis of Cummins' cross section, applied the term "Canyon" to the predominantly limestone and shale sequence stratigraphically equivalent to the Brazos River section. Drake recognized a Chaetetes bearing limestone, or "coral" bed of Cummins (1891) as the basal unit of the Canyon. Above this coral bed, Drake named the units, in ascending order, the Brownwood Shale, the Adams Branch Limestone, the Cedarton Shale, the Clear Creek Limestone, Shale No. 7, a "cherty" limestone, the Hog Creek Shale, the Home Creek Limestone, the Buff Creek Shale and, at the top of the division, a limestone simply described as a Campophyllum bed. Drake's definition of the Canyon included virtually all the resistant limestones in the Colorado River valley that were of Carboniferous age.

Plummer and Moore (1921, table 1) referred to the Canyon as a group and divided it into formations bearing the names of Brazos River valley locations. These formations were further subdivided into members, using the same nomenclature adopted by Drake (1893).

After correlating the Campophyllum bed of Drake to the Gunsight Limestone (Cisco) of the Brazos River valley, Plummer and Moore (1921) moved the upper boundary of the Canyon down to the top of Drake's Home Creek Limestone.

Plummer and Moore (1921) subdivided the lithologic units in the Colorado River valley into couplets of a lower shale and an upper resistant limestone. In the Colorado River valley, the "coral" bed of Cummins (1891) which was recognized as the base of the Canyon by Drake (1893), was renamed the Capps Limestone. Plummer and Moore considered the Rochelle Conglomerate to be of Canyon age and designated it as the base of the Graford Formation, with the Brownwood Shale and the Adams Branch Limestone above the Capps.

Above the Graford Formation, the Brad Formation consisted of the Cedarton Shale, the Clear Creek Limestone, the Placid Shale, and the Ranger Limestone, Drake's "cherty" limestone.

Above the Brad Formation was the Caddo Creek Formation which consisted of the Hog Creek Shale and the Home Creek Limestone.

Hudnall and Pirtle (1931) revised Plummer and Moore's classification only slightly, moving the base of the Canyon from the base of the Rochelle Conglomerate to a thin, impersistant limestone which occurred approximately one hundred feet above the Capps, which they called the Palo Pinto Limestone.

Nickell (1938) followed Hudnall and Pritle's nomenclature as it related to the Canyon Group, but applied the name "Winchell" the the limestone unit previously referred to as the Clear Creek Member of the Brad Formation.

Cheney (1940), as previously mentioned, changed much of the nomenclature and the rank of the units in the region as he attempted to correlate paleontological time boundaries from the mid-continent to the lithostratigraphic divisions of earlier authors of central Texas. Cheney added a new group to the base of the Canyon Series in the Brazos River valley (the Whitt) which corresponded with the Brownwood Shale of Plummer and Moore (1921, table 2). This new stratigraphic interpretation left the Adams Branch as the new basal unit of the Graford Formation and the Winchell (Brad Formation of Plummer and Moore, 1921) as the uppermost unit. This revision left only the Placid Shale and the Ranger Limestone as the units comprising the Brad Formation. The top of the Canyon Series, the Caddo Creek Formation, remained the same with its uppermost unit remaining the Home Creek Limestone.

Cheney and Eargle (1951) expanded the Whitt Formation to include the Adams Branch Limestone, leaving the Cedarton Shale and the Winchell Limestone as the only two members of the Graford Formation. The upper and lower boundaries for the series remained the same. Cheney (1948) changed the name of the Hog Creek Shale (Caddo Creek Formation) to the Colony Creek Shale in order to clarify earlier misapplications of the term "Hog Creek".

Shelton (1958) conducted an indepth paleontologic study of the Strawn-Canyon Series contact, expounding on the fusulinid data cited by Cheney in 1940. In an effort to choose a lithologic unit to mark the boundary, Shelton chose the Capps Limestone as the uppermost unit of the Strawn Series, following the stratigraphic nomenclature established almost eighteen years earlier by Cheney.

Two years later, Eargle (1960, table 1) reapplied the term group to the sequence of limestones and shales previously called the Canyon Series, raising the member units to formation rank.

Subsequent investigations have done little to change the nomenclature since the early 1960's. Some of the more notable investigations were by Laury (1962), Bretsky (1966), Erxleben (1975), and Barnes (1976). Summary charts of the Pennsylvanian nomenclature can be seen in Eargle (1960, Pl. 27) and Roepke (1970, table 1).

For the purposes of this study of the Strawn and Canyon Groups in the subsurface, the nomenclature adapted by Barnes (1976) is accepted (Fig. 5).

STRATIGRAPHY OF THE STRAWN GROUP

Introduction

Only the upper portion of the Strawn Group is present in the study area and rests unconformably on the Ellenburger Group (Ordovician). The upper Strawn limestones identified on electric logs are considered to be, in ascending order, the Goen and the Capps (Fig. 6). Above the Capps is an interval of shales and lenticular sandstones (the Morris sand, the Wilhelm Sand, and the Cross Cut sand) that make up the remainder of the upper Strawn section (Fig. 5).

The Capps Limestone crops out adjacent to the study area in the Colorado River valley and can be projected into the subsurface based on the thick clastic interval which overlies it. Stratigraphically, the limestone that underlies the Capps in the outcrop is the Ricker Station Limestone (Cheney, 1949). Whereas the only occurrence of the Goen Limestone at the surface is in the Brazos River valley. While this lower limestone may in fact be the Ricker Station, the term "Goen" will be used in this study because of its widespread use on oil well scout tickets and completion reports. The Abilene Geological Society, in its north-south stratigraphic section through Concho, Menard, and Kimble Counties in 1962, also used the term "Goen"

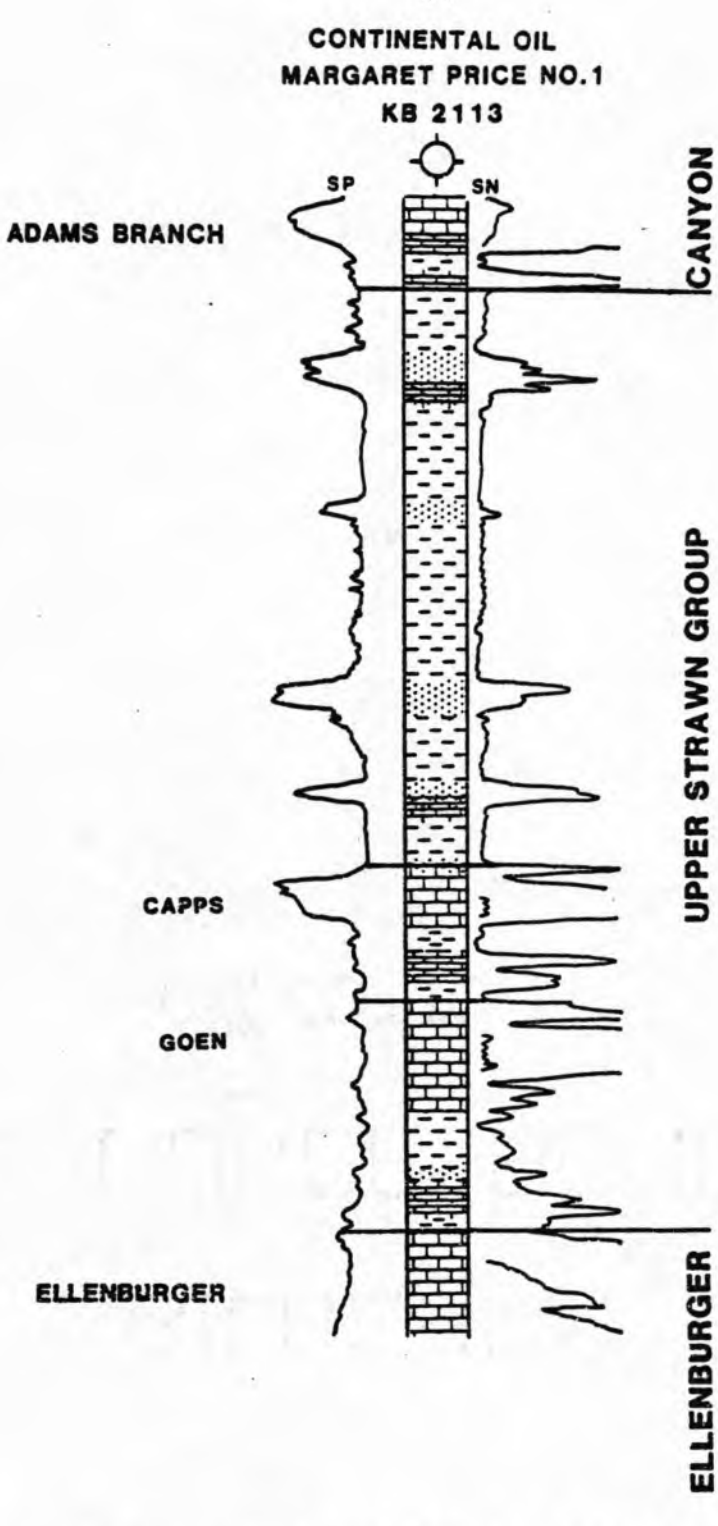

FIGURE 6. TYPE ELECTRIC LOG FOR THE UPPER STRAWN GROUP

to identify on electric logs the limestone unit below the Capps.

The general lithologic character of the units identified on the electric logs was extrapolated from observations made in the field in the Colorado River valley and from the log character.

Because the units under discussion, in the Strawn as well as the Canyon, appear to be cyclic in their depositional character (a terrigenous shale interval capped by a resistive marine limestone), it is within this depositional framework that each of the major units will be discussed.

Goen Limestone Cycle

The Goen Limestone comprises the basal cycle of limestone and shales that rest unconformably on the Ellenberger Group in the subsurface of Concho and Menard Counties. The electric log character of the Goen Cycle is very similar to that of the overlying Capps Limestone and is therefore assumed to be of the same general lithologic character.

The lower section of the Goen cycle is predominantly shale with an increasing percentage of carbonates in the upper part of the unit. As previously mentioned, the stratigraphically equivalent limestone seen in the outcrop is the Ricker Station (Cheney, 1949), a fusulinid packstone with gastropods, brachiopods, and abundant crinoid columnals.

The thick carbonate sections seen in the Goen cycle (Pl. III, well 148) in the northeastern part of the study area do not appear to correlate with the thick sections in the southwest (Pl. II), as they pinch out on either side of a structural high in the Ellenburger (Pl. VII), which strikes northwest-southeast near the Concho-Menard County line.

To the east the Goen thins and eventually pinches out as it approaches the Llano uplift (Pl. V). This stratigraphic pinch-out of the Goen is also evident in Plate VII.

The Goen, present throughout the study area, becomes increasingly more carbonate to the west and clastic to the east across the study area; possibly reflecting the tilting of the Ellenburger paleosurface toward the Midland basin as the Llano uplift became more prominent in the Desmoinesian.

Capps Limestone Cycle

Above the Goen Limestone is a generally thirty to fifty foot thick interval of shales and terrigenous muds capped by two thick carbonate units referred to as the upper and lower Capps Limestone. The upper Capps Limestone was the last broad shelf carbonate unit deposited during the Desmoinesian and served as the paleosurface over which a thick clastic wedge of uppermost Strawn sediments was deposited.

Where observed in the field, the Capps is a dark gray, nodular to wavy bedded limestone abundant in fusulinids and the coral <u>Chaetetes</u>. Locally the Capps may display basal conglomeratic lenses as well as zones where the underlying shales are quite sandy in character, reflecting a cycle of terrigenous influx followed by a quiescent period of carbonate accumulation.

The Capps can be recognized on electric logs throughout the study area as a package of two thick limestone units sepearted by a shale of varying thickness (Fig. 6). While the overall Capps cycle remains almost uniform in thickness across the study area, it thins slightly toward the east and the Llano uplift (Pls. V, VII) where it becomes more terrigenous in character.

Where the Capps crops out to the east of the study area, in Brown County, the upper and lower limestone units are approximately fifteen to twenty feet thick, seperated by a shale generally eight to ten feet thick. To the west toward the Midland basin thicknesses of the limestones may reach eighty feet or more with a very thin shale stringer seperating the upper and lower units (Pl. VI).

Plate IV, a section along what has been described as the axis of the Concho Arch (Cheney and Gross, 1952;

Holmquest, 1955) shows the least variation in thickness of the Capps cycle from east to west but does indicate a thinning of the limestone units on the Bend Arch.

Upper Strawn Shales and Sands, Undivided

In order to facilitate discussion, the thick clastic wedge found between the top of the Capps and the base of the Adams Branch Limestone will be referred to as the "undivided sands and shales" of the upper Strawn. Probably equivalent to the Brownwood Shale Member of Cheney (1940), this predominantly shale interval is easily recognized on electic logs (Fig. 6), and embodies several sandstone units variously named the "Cross Cut", the "Wilhelm", and the "Morris", based on local oil field discoveries in those units.

Where observed at the surface, the sandstones are generally moderately sorted, fine- to coarse-grained litharenites and sublitharenites. Some of the units are locally conglomeratic and contain subrounded chert clasts in their basal section. A good many of the sandstone units show vertical burrows and some even display ripple marked surfaces. Laminar as well as trough crossbeds can be observed in many of the lenticular sandstone units. The lenticular nature of these sands is also seen on the electric logs from the study area.

The gray shales of the upper Strawn, the predominant lithology in the Colorado River valley, weather to a yellowish-brown and contain abundant fossil fauna, including brachiopods, crinoids, bryozoans and fusulinids. It was on the basis of this fauna that Cheney (1940) placed the Strawn-Canyon boundary within this interval.

This thick interval of shales and sandstones, whose geometry would best be described as a clastic wedge, can be seen throughout the study area. This clastic wedge can be seen on Plates V and VII where the interval thickens from approximately eighty feet in the eastern portion of the study area to over five hundred feet thick along the western limits of Concho and Menard Counties. This predominantly clastic interval sometimes displays thin carbonate units that are lenticular in nature (Pl. V, well 59 and 61). These thin carbonate units are generally developed just above the lenticular sandstone bodies.

A net sand map (Pl. IX), constructed to help identify the depositional direction of the clastic influx, indicates that the majority of the sediments prograding on to the Concho platform during the Desmoinesian were derived from the east, possibly the Llano uplift. The lobate pattern of the sands suggest they were deposited by constructive deltaic processes.

STRATIGRAPHY OF THE CANYON GROUP

Introduction

The Canyon Group, an interval of limestone and shale couplets, is recognized on electric logs as seven lithologic units (Fig. 7). Aside from the Adams Branch, which could be considered the capping limestone of a cycle that includes the sands and shales of the upper Strawn, the cyclic nature of the Canyon deposition is quite apparent in the couplets. Each cycle consists of a clastic shale capped by a marine carbonate. Each carbonate marking the period of maximum transgression prior to being inundated by the prograding clastics.

The Palo Pinto Limestone, the basal Canyon unit in the Brazos River valley, was shown to pinch-out in eastern Tom Green and Schliecher Counties (Rall and Rall, 1958) and therefore, is not present in the subsurface of Concho and Menard Counties. Consequently, making the Adams Branch Limestone the lowermost Canyon unit.

Adams Branch Limestone

The Adams Branch Limestone is stratigraphically the lowest of several limestone units of the Canyon Group producing prominant ridges within the Colorado River valley

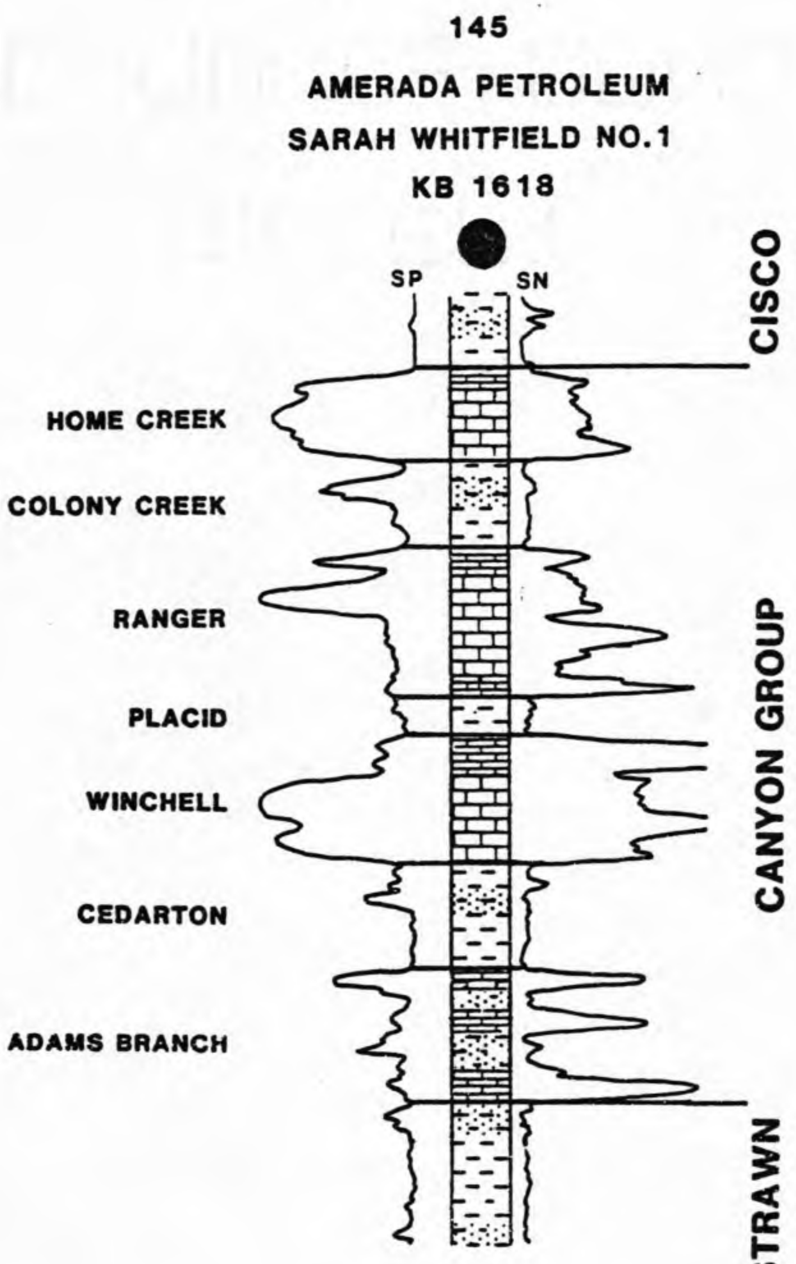

FIGURE 7. TYPE ELECTRIC LOG FOR THE CANYON GROUP

north of the Brady Mountains.

Where observed in the field, in McCulloch County, the Adams Branch is a ten to thirty foot thick limestone unit that is interbedded with thin shale intervals. Dark gray on a weathered surface, the limestone may be very thin-bedded or it may show may show massive wavy beds. Where seen on electric logs, the Adams Branch seems to maintain the same general characteristics into the subsurface (Fig. 7).

The limestone beds of the Adams Branch are highly micritic in nature with abundant phylloid algae and would best be described as an algalpackstone (Dunham, 1962). Other allochems found in the matrix are fusulinids, bryozoans, brachiopods, and locally abundant crinoid fragments.

The Adams Branch varies very little in thickness across the region, from fifty to one hundred feet, but thins to the west, unlike the underlying carbonates of the Strawn Group which thicken westward (Pl. VI). It should be noted that the Adams Branch is thickest over structurally high areas of the Ellenburger (Pl. III). This relationship might suggest that tectonic movement in the Ellenburger during early Canyon time provided topographically positive areas which promoted both the growth and accumulation of calcareous algae, the predominant allochem in the Adams Branch.

Winchell Limestone Cycle

Having a gradational contact with the underlying Adams Branch Limestone, the Cedarton Shale represents the terrigenous, sandy shales and siltstones interval of the Winchell Limestone cycle.

On the outcrop, where it ranges from twenty to eighty feet thick, the Cedarton is primarily composed of mudstone, siltstone, and shale that become more marine to the west as the unit thickens. This depositional pattern is in sharp contrast to the other shales of the Canyon Group that thin westward (Pls. V, VI). It should be noted that the Cedarton thins over highs in the Adams Branch and becomes thickest where the Adams Branch is most thin (Pls. II, III).

Where the Cedarton forms broad valley floors in the Colorado River valley, small localized sandstone bodies comprised of fine- to coarse-grained litharenites can be observed in this predominantly shale unit. These small sand bodies are also recognized on electric logs, primarily in the eastern part of the study area.

Capping the Cedarton shale and marking a period of maximum transgression is the Winchell Limestone, a very resistive, micritic unit that is generally thick-bedded, but may be interspersed with shale intervals two or three feet thick. The electic log character of the Winchell

(Fig. 7) corresponds quite well with the rocks seen on the outcrop.

This unit, described as a packstone, may be locally very abundant in phylloid algae. Brachiopods, crinoids, or bryozoans are also present in the unit, but are sparse.

The subsurface extent of the Winchell can best be seen by means of a structural contour map constructed on top of the unit (Pl. X). The "shale line" represents the southwestern extent of the Winchell, a relationship also seen on Plates III and VII. The Winchell is the thickest unit in the Çanyon Group, attaining thicknesses up to 225 feet along its depositional limits in southwestern Menard County. The Winchell is, for the most part, uniformly thick throughout the study area, averaging about 190 feet.

Buildup in the unit can be correlated with changes in dip in the topography of the Ellenburger limestone (Pls. III, VII). These buildups might be attributed to compaction of underlying delta shales adjacent to the preexisting carbonate buildups in the Adams Branch or continued, mild movements in the Ellenburger creating topographically positive areas that promoted the growth of calcareous algae.

Ranger Limestone Cycle

Overlying the Winchell Limestone and constituting the lower member of the Ranger Limestone cycle is the Placid Shale. It generally consists of three units where it crops out in the Colorado River valley: a lower shale interval, a carbonate unit known as the Corn Creek Limestone and an upper shale unit. The electric log character of the Placid Shale reflects the lithology seen at the surface (Fig. 7). The lower shale, generally about twenty feet of variegated mudstones at the surface thins toward the basin and is overlain by a primarily micritic limestone with a log character similar to that of the Winchell Limestone. The upper shale interval of the Placid is considerably thicker at the surface than the lower unit, but thins southwestward as the Corn Creek Limestone thickens and appears to coalesce with the overlying Ranger (Pl. III). From about the Concho-Menard County line southward, the Placid Shale interval is not distinguishable on electric logs as the carbonates of the Ranger thicken (Pls. III, IV, VII).

Where it crops out in the Colorado River valley, the Ranger Limestone forms a prominent northeast trending escarpment from the Brady Mountains to Brownwood. Observed in a road cut just west of Brownwood, the Ranger is a package of two massive, nodular beds of microgranular, siliceous limestone seperated by a thin clay seam, a relationship observed on the electric logs as well (Pls. III, IV).

Paleontologically, the Ranger is quite similar to the other limestones of the Canyon Group, containing fusulinids, bryozoans, brachiopods, phylloid algae, and crinoid fragments.

Having approximately the same areal distribution as the overlying Home Creek Limestone (Pl. XI) the Ranger thickens to the southwest (Pls. II, VII) where its maximum thickness of 150 to 160 feet is observed near its depositional limits.

Home Creek Limestone Cycle

The contact between the Ranger Limestone and the overlying Colony Creek Shale, a terrigenous shale comprising the lower interval of the Home Creek cycle, appears to be gradational in character where it crops out in Brown County.

Predominantly a greenish-yellow mudstone with small limestone lenses, the Colony Creek thins to the southwest and is virtually nonexistent as it approaches the thick carbonate buildups near the depositional limits of the overlying Home Creek (Pls. III, IV).

The thickness of the Home Creek cycle varies very little across the study area and where the carbonates of the Home Creek thicken, they do so at the expense of the underlying shale (Pls. II, V). In other words, the capping carbonate unit appears to "build down" rather than form some type of positive carbonate mound. This "building down" is also seen in the Ranger cycle but is not apparent in the Winchell sequence (Pls. III, IV, VII).

The Home Creek Limestone is similar in character to the Ranger Limestone and appears on electric logs to be composed of two or three laterally persistent carbonate units seperated by thin shale intervals (Fig. 7). Where observed on the outcrop, these carbonate units are dark gray, wavy-bedded, and often locally fossiliferous. Being primarily micritic in character the Home Creek contains bryozoans, brachiopods, pelecypods and abundant phylloid algae and would best be described as a packstone (Dunham, 1962).

The depositional limits of the Home Creek can best be observed by means of a structural contour map on the top of the uppermost unit of the limestone package. From thicknesses of forty to fifty feet along the axis of the Concho Arch (Pl. IV) the Home Creek thickens to the southwest where it reaches thicknesses of 110 to 130 feet near its depositional limits (Pl. II). This westward thickening is also evident on Plates VI and VII.

DEPOSITIONAL SYNTHESIS

The limestones and shales of the upper Strawn Group rest unconformably on the Ellenburger Group. The onlapping nature of the lower intervals of the Goen cycle in relation to highs in the Ellenberger (Pl. III) suggest that the Ordovician limestone may have been subareally exposed as late as the middle Desmoinesian. The Goen cycle eventually produced a broad carbonate shelf over which the prodelta shales of the Capps cycle were deposited from the east toward the Midland basin.

As tectonic activity related to the encroaching Ouachita Fold Belt waned and the influx of terrigenous sediments decreased, the Capps Limestone began to accumulate on the broad, shallow shelf whose edge was to the west of the study area in Schleicher County (Adams, 1951, Fig. 3). The thickening of the limestone to the west was probably a result of less terrigenous influx and a rate of carbonate accumulation that exceeded the rate of subsidence caused by the compaction of the underlying shales. The abundance of Chaetetes in the Capps would suggest that the prodelta shelf over which the unit was deposited had a shallow water marine environment with good water circulation and plenty of light; a time of maximum transgression.

Above the Capps is the thickest sequence of terrigenous sandstones and shales in the upper Strawn. This westward-thickening clastic wedge probably marked the most intense period of tectonic activity in the middle Pennsylvanian in the region. The prograding deltas, derived from the Ouachita system to the east, reached their maximum thickness during this period (Fig. 8). The character of the electic logs in this interval (Fig. 6) and the net sand map constructed (Pl. IX) suggest the deltaic system of the upper Strawn to be similar to that of the modern Mississippi River delta (Rainwater, 1966).

The clastic wedge formed by these upper Strawn sediments changed the gradient of the subsea depositional surface and allowed the accumulation of the Adams Branch Limestone, which thins to the west, in contrast to the geometry of the other limestones deposited in the Canyon Group that generally thicken to the west (Pls. III, VI). A quiesent period of deposition followed the terrigenous influx of the upper Strawn as the algal-rich Adams Branch Limestone began to accumulate. The presence of highly bioturbated beds in the lower Adams Branch and the presence of unabraided fossils lend evidence to the low energy conditions that accompanied deposition. Thick areas in the Adams Branch correspond to highs on the Ellenburger limestone, suggesting mild folding of the Ellenburger

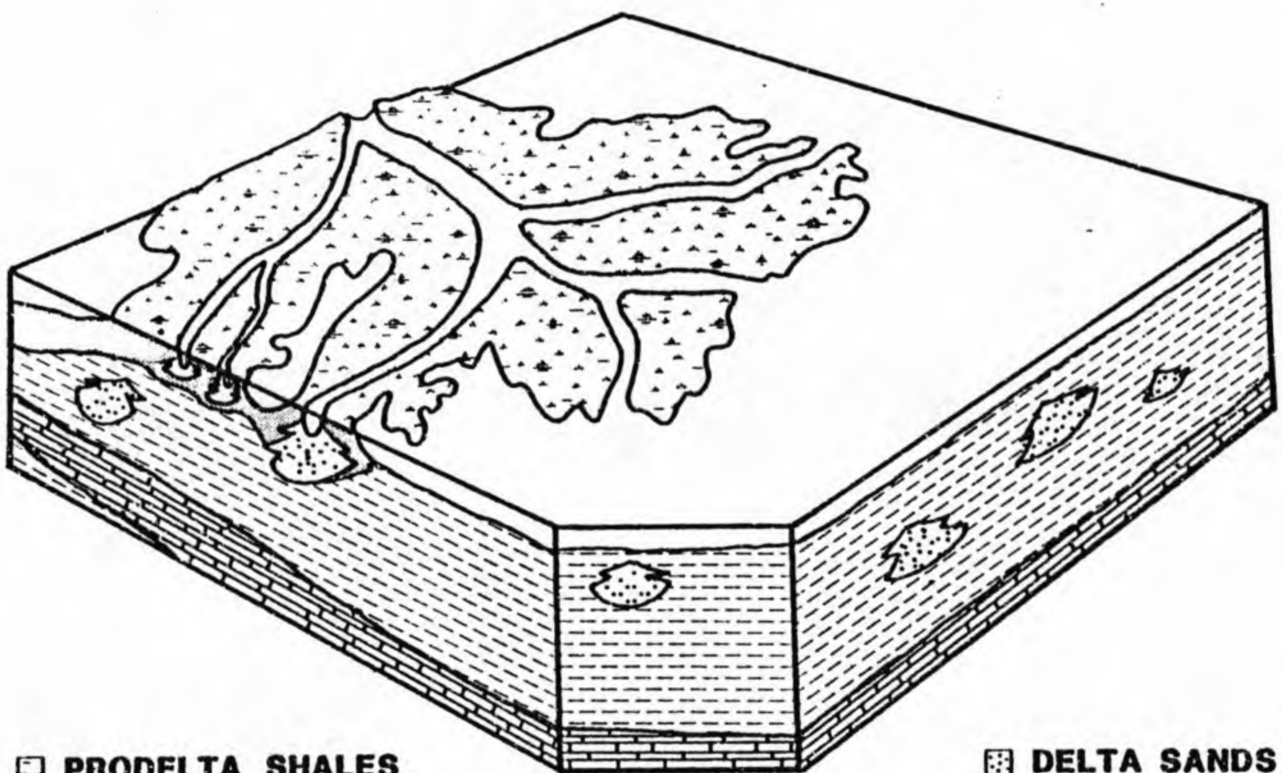

FIGURE 8. DEPOSITIONAL MODEL FOR THE UPPERMOST STRAWN GROUP, adapted from Fisk and others(1954)

during deposition of the early Canyon Group. This structuring allowed the maximum and most rapid growth of carbonate banks as phylloid algae and crinoids flourished in the nutrient rich shallow water over paleohighs created on the delta plain surface. These carbonate banks, however, probably never showed a topographic relief more than a few centimeters high (Ball and others, 1977).

Movement of the Ellenburger probably continued during deposition of the Winchell cycle, as evidenced by thick Winchell deposits corresponding to structural highs in the Ellenberger (Pls. III, VII), similar to Adams Branch deposition. The abundance of variegated muds and clays and thick sand bodies within the Winchell would indicate that the Winchell was deposited on the more proximal portion of the prodelta surface.

Sea level fluctuated very little during deposition of the Canyon Group as evidenced by the lack of evaporites or dolomitic lithologies and the absence of any signs of subareal exposure.

The next depositional cycle, the Ranger Limestone cycle, was initiated with the influx of prodelta shales (the Placid Shale) across the Winchell paleosurface. When the deposition of the prodelta sediments ceased, carbonate accumulations became dominant and widespread. Areas of greater light intensity and nutrient-rich water near the distal edges of the prodelta shales promoted the growth of calcareous algae which in turn served to produce and trap carbonate muds seen in the Ranger. Studies of modern mud sedimentation along the Mississippi delta (Fisk and others, 1954) have shown that rapidly deposited muds at the distal edges of a delta are, for the most part, unconsolidated and therefore retain higher than normal porosities allowing for easy compaction. If carbonate sedimentation were to flourish on this submerged, shallow shelf prodelta surface, after abandonment of the distributary channel (as in the Ranger), it would probably be limited in its upward growth by wave base. At the distal edge of the prodelta wedge, continued compaction of the underlying unconsolidated muds would cause the surface upon which the carbonates were accumulating to subside, leaving the interval between the sediment surface and wave base constant. The geometry of the resulting carbonate unit would take the form of a uniform blanket of carbonate mud across the prodelta surface and wedge-like increases in thickness at its edges (Fig. 9). By this process, thicker accumulations of algal rich carbonate sediment may occur without necessarily developing a shoal or bank (Roepke, 1970). By this model, these algae were probably more of a source of building material rather than important builders. This type of relationship is seen on all the stratigraphic

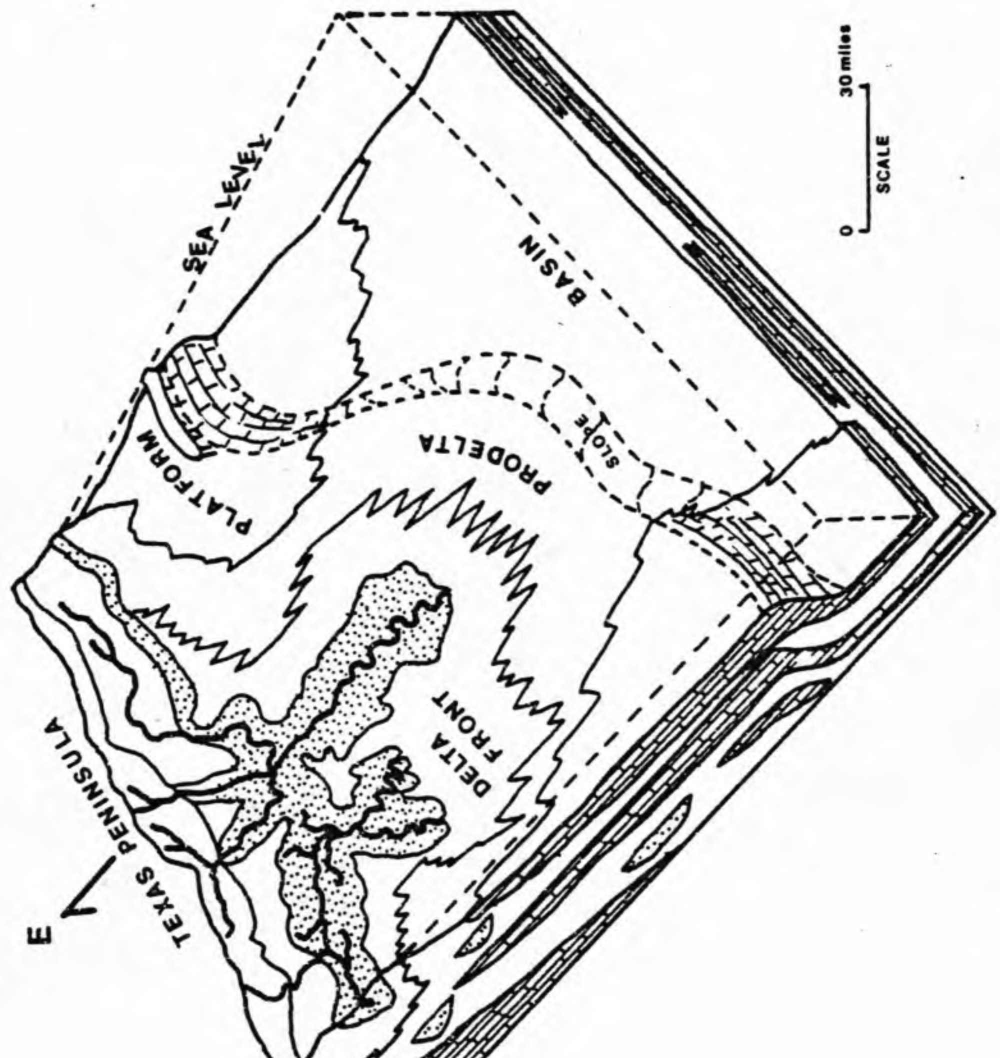

FIGURE 9. DEPOSITIONAL MODEL FOR THE CANYON GROUP

cross sections (Pls. II-VII) and best serves as the model for deposition of the Ranger and Home Creek cycles. The abundance of pellets, in the Home Creek and Ranger the articulate nature of brachiopods, and the extensive burrowing in the base of the units suggests a very stable environment that was influenced very little by current or wave action.

At the top of the Home Creek Limestone, the gradational contact with the overlying shales marks the beginning of the next cycle of deltaic deposition seen in the Cisco Group.

CONCLUSIONS

1) The most intense period of activity along the Ouachita Fold Belt during the Strawn and Canyon deposition occurred in the late Desmoinesian and early Missourian as a thick clastic wedge prograded across the Concho platform. This fluvial-deltaic system was deposited between the top of the Capps and the base of the Adams Branch Limestone.

2) The sea level during deposition of the Strawn and Canyon Groups fluctuated very little. The cyclic nature of the deposits was due to periodic influxes of clastics over a slowly subsiding shelf that allowed the accumulation of carbonates as terrigenous influences waned.

3) Carbonate buildups on the Concho Platform occurred as the result of two processes: 1) carbonate accumulations on paleotopographic highs related to structuring in the Ellenberger and 2) thickening of carbonates by compaction near the distal edges of unconsolidated prodelta muds.

RECOMMENDATIONS FOR OIL AND GAS EXPLORATION

Concho and Menard Counties might be considered as somewhat of a "No-Man's Land" in the search for hydrocarbons. Major companies seldom drilled, but owned acreage, worked it with crude seismic and gravity meters looking for structural highs in the subsurface. Early surface highs mapped and drilled for the most part were dry.

The major producing interval north of the Ellenburger high (Pl. VIII) along the Concho-Menard County line is the Goen Limestone, described as a stratigraphic trap with "down dip water drive and up dip porosity pinch-out". Recent production maps of the region (Geomap No. 317, 1977) indicate production along structural strike of the Strawn-Canyon series. This suggests that production is related to Permian structuring, rather than depositional influences such as facies changes. Most of the limestone units in the area show good porosity on electric logs but produce no hydrocarbons where all the necessary ingredients of source (prodelta shales), seal (overlying shales), and trap (phylloid rich limestones) are available. It could be that flexuring due to post-Permian movement could have fractured the Goen providing the other key ingredient in production--permeability.

I recommend that structural maps on a smaller interval than those provided in this report be constructed along this trend to detect rapid changes in dip which could be indicative of flexuring and in turn fracturing of the reservoir rock.

South of the Ellenburger high the most prolific producing zones are within sand bodies of the upper Strawn delta complex. The better exploration technique in this area would be to map the individual producing zones and look for stratigraphic pinch-outs against high area created by movements in the Ellenburger during the Permian.

APPENDIX I

Well Log Information

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
1	Ray Smith	Dusek #1	-2800	-1434	-1259
2	R.H. Cat and Reynolds	Kudlacek #1	-2600	-1435	-1255
3	Curtis Hankamar	Murphy #1	-2739	-1549	-1404
4	E.C. Johnston Co.	J.C. Brosig #1		-1272	-1165
5	J.H. Purvis	F. Higginbotham #1	-2631	-1391	-1251
6	James K. Anderson	Campbell #1-A	-2610	-1640	-1455
7	Union Production	J.S. Campbell #1	-2760	-1625	-1455
8	B.G. Energy	Werner #1	-2400	-1145	-1045
9	R. Lacy	#3 Smith Ld. & Ctl. Co.		-1270	-1005
10	Connally Oil	Noack #1	-2644	-1464	-1236
11	B.L. Wooley	Sims #1	-2389	-1254	-1014
12	Blanco Oil	B.O. Sims #1	-2395	-1185	- 955
13	Seaboard Oil	Ellen Sims #1	-2335	-1198	- 968
14	Allison & Prestridge & Westex	O.C. Sims #1	-2296	-1176	- 936

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
15	Davis Oil Co.	H.R. Hoffman #1	-2251	-1135	- 920
16	BACA Drilling	James A Trail #1		-1111	- 896
17	Aztec Oil and Gas	O.H. Rezzlle #1	-2199	-1164	- 879
18	George Strake	Smith Land & Cattle	-2355	-1266	-1001
19	Tucker Drilling	F.G. Keele #1	-2679	-1469	-1204
20	West Central Drilling	Carter Est. #1	-2423	-1414	-1109
21	Jack Grimm	Lehr #1	-2215	-1175	- 910
22	Gulfshore Oil & Tucker Drilling	R.T. Trail #1	-2137	-1037	- 857
23	Wilmar Oil	Trail Ranch #1		- 962	- 762
24	Holland Oil	Ella Houston #1	-2036	- 926	- 731
25	Texas American Oil	O. Sultemeier #1	-1995	- 895	- 700
26	Continental Oil	W.M. Hartgrove	-1946	- 856	- 651
28	May Petro	#1 Hartgrove		- 797	- 682
29	Hanover Manag.	W.M. Hartgrove Est. #1		- 853	- 648

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
30	Resources Investment	Schultz #1	-1873	- 823	- 623
31	Carlton Drilling	Hutchson #1		- 978	- 698
33	Progress Petro.	M. Sansom #1	-1800	- 740	- 530
34	Continental Oil	H.R. Campbell "A" #1	-1908	- 878	- 673
35	Carlton Drilling	Cole #1		- 832	- 632
36	Continental Oil	S.L. Hartgrove "A" #1	-1894	- 884	- 684
37	Sunray Mid-Continent	Meixner #1	-1961	- 891	- 706
38	J.R. Hatch	Meixner #1		- 921	- 721
39	Termo Co.	#1 Edwards	-2025	- 974	- 790
40	Petro. Exploration & Development	H.A. Stephens #1	-1985	- 949	- 759
41	J.R. Hatch	Meixner #2		- 889	- 689
42	MGF Oil Co.	Tyler #1		- 844	- 644
43	Holland Oil Co.	Sansom Cattle #1	-1713	- 743	- 458
44	Mobil Oil Co.	Selman Cave Unit #1	-1769	- 784	- 579

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
45	Sunray Mid-Continent	J.R. Cox #3		- 831	- 636
46	Humble Oil	J.R. Cox Jr. #1		- 869	- 684
47	Sunray Dx Oil	Barfknecht #2		- 900	- 715
48	Sunray Mid-Continent	R.L. Carter #7		- 880	- 695
49	Sunray Dx Oil	R.L. Carter		- 893	- 713
50	Roy L. Carter	Carter "B" #4		- 847	- 657
51	Sun Oil Co.	L.G. Watkins #2		- 863	- 673
52	Holland Oil & Gas	Mikeska 5-A	-1926	- 876	- 681
53	Sunray D-x Iol	A.E. Kitchens #1-B		- 820	- 620
54	Sun Oil	Ed Speck "A" #6		- 849	- 649
55	Sun Oil Co.	Speck #4		- 833	- 643
56	Progress Petro	F.R. Speck #2A	-1684	- 829	- 649
57	John Chalmers	Marthia Judge #1		- 980	- 800
58	J.A. March	Moelke Melton Frog Pond #1	-2227	-1091	- 911

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
59	Sunray DX Oil	Annie M. Ellis #2	-1995	- 909	- 834
60	Sun Oil Co.	Ed Speck "A" #5		- 817	- 617
61	Continental Oil	Margaret Price #1	-1735	- 757	- 537
62	Continental Oil	J.A. Hall #1	-1627	- 707	- 487
63	Jack O. Frizzell	J.A. Hall #1		- 720	- 485
64	Carl D. Lang	J.A. Hall #2		- 683	- 448
65	Carl D. Lang	J.A. Hall #1		- 630	- 395
66	Eltex Ltd.	Martin #4	-1777	- 807	- 537
67	Lone Star Producing	D.M. Winburn #1		- 630	- 440
68	Delta Gulf Inc.	Jacoby Well #1		- 611	- 381
69	Sun Oil Co.	G.H. Spiser #1		- 798	- 598
70	Sun Oil Co.	Armor-Caffey #1		- 823	- 623
72	R.P. Fisher	Byrde Cox #2		-1074	- 900
73	Lon H. Cron	Byrde Cox #3		-1045	- 790
74	J.R. McLean	Chambers Est. #1-B		-1161	- 856

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
75	R.P. Fisher	Denis #1		-1251	- 906
76	J.R. McLean	Denis #1	-2579	-1359	- 979
77	Murray, Seneca	Chambers Est. #1		-1341	-1001
81	J.R. McLean	J.M. Chambers #1	-2417	-1207	- 887
82	General Crude Oil	J.C. Denis #1	-2354	-1159	- 924
83	Progress Pet. Co.	Henderson #1	-2388	-1168	-1018
84	Guy Mabee	Denis #1	-2159	-1049	- 629
85	D & B Oil & Gas	1-42 J.E. Henderson		-1017	- 602
86	Internorth Inc.	Concho Co. Ranch 56-1	-2099	-1059	- 569
87	Sunray Dx Co.	J.E. Henderson #7	-1954	- 928	- 623
88	Sunray Mid-Continent	J.E. Henderson #1	-2002	- 902	- 617
89	Sunray Dx Oil	J.E. Henderson #9	-1898	- 883	- 618
90	Sunray Mid-Continent	J.E. Henderson #4		- 952	- 702
91	Sunray Dx Oil	J.E. Henderson #8	-1890	- 844	- 609
92	Tucker Drilling	Cora Henderson #1	-2069	- 962	- 717

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
93	D & B Oil	J.E. Henderson 1-54		- 915	- 435
94	Sun Oil Co.	J.E. Henderson #1		- 917	- 687
95	Clem George	Owens #1		- 851	- 441
96	Tucker Drilling	Canning 51-1		- 791	- 526
97	Sunray Dx Oil	J.R. Canning #1	-1932	- 854	- 584
98	Phillips Petro.	#1 Duncan D		- 980	- 685
99	Phillips Petro. Co.	Duncan C-#3	-2026	- 926	- 626
100	Phillips Petro. Co.	#1 Duncan C	-2099	- 953	- 688
101	Seagull Int'l Explor.	Morrix Miller #1		- 897	- 682
102	Phillips Petro.	Duncan C#2		- 916	- 706
103	Tucker Drilling Co.	Henderson #1-B		-1262	---
104	Pan Am. Petro. Corp.	A Henderson #1	-2302	-1112	- 957
105	Blue Danube Oil	Matthews #1-23		-1197	- 997
106	Pan Am. Petro. Corp.	A. Henderson #1		-1267	-1032
107	Tucker Drilling	A.R. Henderson		-1150	- 875

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
108	Ray Smith Drilling	A Henderson #3	-2240	-1030	- 845
109	No. Amer. Explor. Co.	Morris Miller #1		- 930	- 655
110	Tucker Drilling	Miller #2	-2030	- 730	- 380
111	No. Amer. Explor. Co.	#2 Morris Miller		- 736	- 441
112	Tucker Drilling	Miller #1		- 823	- 383
113	So. Minerals Corp.	A.B. Henderson #1	-1713	- 713	- 383
114	Davisson & Fitzgerald	Dan Sorrell #1		- 683	- 343
115	Adelente Petro	G. Bunger #1		- 608	- 318
116	E.R. Perkins	Williams #1		- 568	- 228
117	H.W. Klein	Lillie Blaylock #1	- 1651	-----	-----
118	Texrado Oil Co.	M. Lubeke #1	-1338	- 446	- 211
119	Morrow Resources	Pfluger #1-H	-1226	- 371	- 126
120	Damson Oil	Pfluger #1	- 807	- 92	+ 162
121	H.A. Birdwell & Son	J.L. Curry		- 8	+ 197
122	Roy L. Carter	C.W. Schultz #1	-1410	- 516	- 266

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
123	Northern Ordinance Inc.	Lee Community #1	-1379	- 489	- 264
124	Way and Mills Inc.	L.L. Armor #1	-1449	- 519	- 279
126	W.W. Murray	Watkins #1	-1513	- 578	- 333
128	Northern Ordinance	Drinkard Community #1	-1325	- 455	- 205
129	Northern Ordinance	I.R. Drinkard #1	-1338	- 458	- 218
130	Roark and Hooker	A. Corbell #1	- 752	+ 8	+ 238
131	Mae Belcher	W. Lovelace A-1	- 642	+ 82	+ 332
132	N. American Explor.	Ledbetter Estate	- 591	+ 130	+ 375
133	James H. Anderson	E.L. Carter #1		+ 7	+ 257
134	Dow Chemical	Baptist Foundation 1-A	- 219	+ 397	+ 641
136	James H. Snowden	E.A. Taylor	- 428	+ 292	+ 557
137	Lamb and Ford	Bessie Baker #1		+ 401	+ 616
138	Cosden Pet. Corp.	G.W. Jenkins	- 451	+ 179	+ 423
139	Simpson-Fell	J.J. McCall #1	- 474	+ 231	+ 466
140	Sherwood B. Owens	V.C. Whitworth 1-B		+ 104	+ 354

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
141	Sherwood B. Owens	Whitworth 1-C	- 668	+ 207	+ 382
142	Amerada Pet.	Buie #1	-1140	- 133	+ 87
143	Amerada Pet.	Buie #3		- 181	+ 19
144	Amerada Pet.	Buie #4		- 284	- 49
145	Amerada Pet. Corp.	Sarah L. Whitfield #1	-1240	- 282	- 32
146	Fisher & Webb & Dixon	Mustang Ranch #1-1835	-1307	- 229	- 84
147	Fisher & Webb & Dixon	Riverside Ranch #1-2	-1350	- 260	- 80
148	S.C. Herring	Myrt Stephens #1	-1347	- 252	- 67
149	H.A. Birdwell & Son	Barr #1		- 484	- 229
150	M. Brad Bennett	Clara Conley #1		- 718	- 418
151	Robert Klabzuba	C. Schwethelm #2		- 906	- 661
152	W.J.C. Engn. & Man.	Williams #1		- 790	- 645
153	Holland Oil Co.	Scott Hartgrove #1	-1830	- 740	- 500
154	Brad Bennett Inc.	Tickle #1968		- 581	- 381
155	Magnolia Pet. and Son	W.C. Fuller #1	-1593	- 558	- 368

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
156	Skelly Oil	S.A. Hartgrove #1	-1294	- 364	- 164
157	Fisher-Webb	H.S. & N. Ranch #2-51		- 335	- 140
158	Fisher-Webb & Dixon	H.S. & N. Ranch #1-51	-1351	- 326	- 141
159	Fisher-Webb Inc.	J. Williams #1	-1431	- 385	- 195
160	Fisher Webb	Glass #1		- 332	- 167
161	Charles E. Long	Daisy Barr #1	-1558	- 533	- 333
162	Martin & Roberts	#1 Sidney Greebon	-1425	- 485	- 245
163	Holland Oil Co.	Sansom #1-126	-1627	- 622	- 397
164	The Texas Co.	Rainwater #1	-1500	- 515	- 320
165	J.D. Burk Joint	Burk #1	-1404	- 524	- 304
166	Seaboard Oil of Delaw.	J.C. London JC #1	-1304	- 387	- 147
167	Farmland Intl. Energy	Stansberry #1	-1516	- 561	- 306
168	Sunray DX Oil	F.T. Stansberry #1	-1475	- 555	- 315
169	Humble Oil	C.E. Jones #1	-1338	- 438	- 213
170	Fisher Webb	J.H. Stansberry #1-1		- 424	- 219

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
172	Saxon Exploration	J.M. Simpson	-1345	- 480	- 250
173	Fisher-Webb	J.H. Stansberry #1-8		- 457	- 227
174	Hovgard & Fitzgerald	W.T. Shaver #1	-1239	- 414	- 169
201	Anadarko Prod.	J.C. Sorrell #1	-2200	-1023	- 758
202	Tucker Drilling	R.A. Tisdale #1	-2312	-----	-----
203	Russell Maguire	H.W. Speck Well #1	-2098	- 813	- 538
204	Rumson Prod.	Frank W. Speck #1		- 738	- 473
205	Ryder Scott Manag.	Speck #1		- 723	- 473
206	Whiffen Est. Inc.	F. Wilhelm #1	-1812	- 727	- 417
207	Shenandoah Oil Co.	Speck #1		- 710	- 440
208	Tucker Drilling	Mary E. Rogers #1	-1906	-----	- 546
209	Lloyd Patton	U.W. Rogers "D" #1	-1895	-----	- 590
210	McGrath & Smith	#1 Mary E. Rogers	-1915	-----	- 575
214	Tucker Drilling	L.E. Callan #2	-2247	-1227	-----
217	Tucker Drilling	L.E. Callan #1	-2131	-----	-----

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
220	Rhodes Drilling	Tomlinson #1	-2031	-----	-----
222	McAlester Fuel Co.	B.S.A. #1	-2337	-1164	-----
227	Sun Oil	S.H. Allixon	-1247		+ 63
228	Jack F. Grimm	Frank Wilkinson #1	-1407		- 130
229	Jack F. Grimm	F.L. Wilkinson #1	-1226		- 1
230	United N. & S. Dev.	W.J. Wilkinson #1	-1170	-----	- 15
231	F.E. Shaheen Jr.	Harrison #1-B		- 559	- 324
232	F.E. Shaheen	H. Harrison #1	-1635	- 605	- 285
233	Fred G. Brown	V.L. Davis #1		- 595	- 230
234	Tucker Drilling	V.L. Davis #1		- 510	- 230
235	McGrath & Smith	M. Wilhelm #2		- 486	- 276
236	Wayne Allison	Fritz Volkmann #1-A	-1638	- 533	- 198
240	Shaheen & Sons	Joe F. Wilhelm #1		- 519	- 169
241	Petro. Corp. of Texas	J. Wilhelm #5		- 493	- 183
242	General Crude	Joe Wilhelm #4		- 466	- 171

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
244	J.R. McLean	Menzies #1		- 395	- 146
245	J.R. McLean	A. Menzies #16		- 458	- 128
246	Hovgard & Fitzgerald	L. Jacoby #4		- 389	- 89
248	Tucker Drilling	W.S. McKee #1	-1230	- 305	- 68
249	Buddha Oil	1 Clark Pfluger		- 234	+ 11
250	Morrow Resources Inc.	Swain "C" #1		- 204	+ 31
251	Tucker Drilling	Swaim #2-C	- 918	- 193	+ 47
252	Hovgard & Fitzgerald	B.K. Neel #1		- 276	- 11
253	Honolulu Oil	B.K. Neel #1	-1004	- 234	+ 56
254	Terra Resources	M. Pfluger #1-A		- 134	+ 171
255	Champlin Oil Ref. Co.	Pfluger-Clark #1		- 94	+ 156
256	L.E. Scherck	Dan Sorrell #1	- 675	+ 10	+ 270
257	Dixon	Smith #1		- 20	+ 235
258	Honolulu Oil Corp.	G. Kothmann #1	- 903	- 172	+ 153
259	Wayne Petroleum	W.S. Menzies #1		- 301	+ 39

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
260	J.R. McLean	W. Menzies #1		- 344	+ 16
261	D.L. Choate & Wico Oil	W. Menzies #1		- 353	- 8
262	Don Whittaker	Baker #1	-1386	- 421	- 76
263	Sunray Dx Oil	S. Wilkinson #2	-1202	- 307	- 67
264	Sunray Dx Oil	S. Wilkinson #1	-1068	- 233	+ 72
265	F.E. Shaheen	G.W. Kothmann #1		- 208	+ 94
266	H.M. Oil Co.	#1 Kothmann		- 113	+ 167
267	J.D. Tompkins	Mabel Wilkinson #1	- 978	- 73	+ 157
268	Skelly Oil	L.B. Grandstaff #1	-1038	- 74	+ 168
269	Skelly Oil Co.	Grandstaff #3		- 51	+ 234
270	Skelly Oil	Ada Smith #1	- 553	+ 117	+ 372
271	Edwin & Amy Hopkins	Betsy Gainer #1	- 606	+ 104	+ 384
272	James P. Dunigan	Grandstaff #1		+ 106	+ 428
273	Barron Kid	Neel #1	- 799	-----	+ 411
274	Nordan Oil & Gas	Bankston #1		-----	+ 330

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
275	Nordan Oil & Gas	#3 Brandenberger Est.	- 889	-----	+ 301
276	Terra Resources Inc.	H.E. Parish #1		-----	+ 480
277	Thomas Drilling	Jack E. Allison #1	- 945	+ 42	+ 332
278	Deep Rock O-1	M.C. Bevans #2	-1327	-----	- 22
279	G.W. Strake	O. Bevans #2	-1113	-----	+ 132
280	George W. Strake	O. Bevans #1	-1097	-----	+ 196
281	Texas Oil & Gas	Bevans #1	-1072	- 62	+ 183
282	Wayne Petroleum	O.B. McCutcheon	-1147	-----	0
283	Deep Rock Oil	Bevans #1	-1240	- 300	-----
284	Northern Natural Gas	McGowan 28 #1		-----	-----
285	Lauderdale & Straughan	Owen & Decker Womack2	-1532	-----	-----
286	Tucker Drilling	Bevans #1	-1393	-----	-----
287	Lauderdale & Straughan	Owens&Decker Womack #1	-1462	-----	-----
288	Lauderdal & Straughan	McNamara #1	-1416	-----	-----
289	Champlin & Strake	J. McNamara #1	-1326	-----	-----

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
290	Hovgard & Fitzgerald	W & J. McNamara #1	-1446	-----	-----
291	Wayne Petroleum	J. McNamara #1-A-43	-1267	-----	-----
292	Pam D. Crawford	J & W McNamara #1	-1399	-----	-----
294	Wayne Petroleum	L. Williamson #1-60	-1094	-----	+ 381
295	Gas Producing	M.Henderson #1		-----	+ 458
296	Fox and Ransdell	Powell #1		+ 144	+ 419
297	Dan E. Whatley	G.L. Schneider #1		+ 245	+ 565
298	Wayne Petro.	A.A. Williamson #1-166	- 62	-----	+1037
299	Wayne Petroleum	D.R. Nasworthy #1-165	- 156	-----	+1012
300	H.M. Naylor	C.R. Nasworthy #1	- 130	-----	+ 970
301	Wayne Petro.	Ruby Sieker #1	- 86	-----	+1017
302	Wayne Petro.	A.A. Wilimson #1	- 223	+ 352	+ 753
306	No. Natural Gas	#1 Whitehead		+ 273	+ 461
307	Davisson & Fitzgerald	Gene Whitehead #1	- 424	+ 261	+ 466
308	No. Natural Gas	Whitehead #1-14		+ 378	+ 580

Well No.	Operator	Name	Subsea Elevations		
			Ellenburger	Winchell	Home Creek
309	J.H. Purvis	W.E. Volkmann #1		+ 508	+ 693
310	Norman Oil Corp.	M.S. Leggett #1	+ 153	+ 673	+ 878
311	Dow Chemical Co.	Baptist Foundation	+ 149	+ 705	+ 954
312	C.E. Jacobs	M.S. Leggett #1	+ 266	+ 741	+ 966
313	Nordan Oil and Gas	Speak Est. #1	+ 333	+ 783	+1008
314	Nordan Oil and Gas	Speak Est. #2		+ 789	+1014
315	Fred G. Brown	Bobby R. Sykes #1	+ 295	+ 780	+1000
316	Fred G. Brown	Bobby Sykes #2		+ 798	+1003
317	Fred G. Brown	Carbell #1-A		+ 772	+ 977
318	Nordan Oil & Gas	Whitehead #2	- 521	+ 89	+ 319
319	Wayne Petro.	C.A. Martin N1-494		-----	+ 805

REFERENCES

Abilene Geological Society (1962) North-south stratigraphic cross section: Concho, Menard and Kimble Counties, Texas.

Adams, John Emery et al. (1951) Starved Pennsylvanian Midland basin: Am. Assoc. Petrol. Geol. Bull., v. 35, p. 2600-2607.

Ball, S.M., Pollard, W.D., and Roberts, J.W. (1977) Importance of phylloid algae development of depositional topography--realty or myth?; in Reefs and Related Carbonates--Ecology and Sedimentation, eds. Frost, S.H., Weiss, M.P. and Saunders, J.B.: Am. Assoc. Petrol. Geol. Studies in Geology No. 4, p. 239-260.

Barnes, V.E. (1976) Geologic Atlas of Texas, Brownwood Sheet: Bureau of Economic Geology, University of Texas.

Barnes, V.E. and Bell, W.C. (1977) The Moore Hollow Group of central Texas: Univ. Texas Bur. Econ. Geology Rept. Inv. 88, p. 80-84.

Barnes, V.E., Boucot, A.J., Cloud, P.E., Miller, R.H., and Palmer, A.R. (1966) Silurian of central Texas: A first record for the region: Science, v. 154, p. 1007-1008.

Bretsky, Peter Jr. (1966) Stratigraphic and carbonate petrology of the Pennsylvanian upper Canyon Group in Stephens and Palo Pinto Counties, Texas; in papers on Pennsylvanian stratigraphic problems in north-central Texas: Graduate Research Journal, v. 35, p. 105-137.

Brown, L.F., Jr. (1973) Pennsylvanian rocks of north- and west-central Texas: an introduction; in Brown, L.F., Jr., Cleaves, A.W., II, and Erxleben, A.W., Pennsylvanian depositional systems in north-central Texas; a guide for interpreting terrigenous clastic facies in a cratonic basin: Univ. Texas Bur. Econ. Geology Guide book 14, p. 1-9.

Cheney, M.G. (1940) Geology of north-central Texas: Am. Assoc. Petrol. Geol. Bull., v. 24, p. 65-118.

_______ (1948) Study of lower Permian and upper Pennsylvanian rocks in Brazos and Colorado River valleys of west-central Texas, particularly from Coleman Junction to Home Creek limestones: Abilene Geol. Soc. Guidebook, June 11-12, 1948, 20 p.

_______ (1949) Pre-Cisco type localities, Brownwood-Ranger-Mineral Wells area: Abilene Geol. Soc. Guidebook, p. 3-47.

Cheney, M.G., and Eargle, D.H. (1951) Geologic map of Brown County, Texas. Univ. Texas Bureau of Econ. Geology.

Cheney, M.G., and Goss., L.F. (1952) Tectonics of central Texas: Am. Assoc. Petrol. Geol. Bull., v. 36, p. 2237-2265.

Cloud, P.E., Jr., and Barnes, V.E. (1948) The Ellenburger group of central Texas: Univ. Texas Bureau of Econ. Geology Pub. 4621, 478 p.

Cummins, W.F. (1891) Report on the geology of northwestern Texas: Texas Geol. Survey, 2nd Ann. Rept., p. 357-552.

Drake, N.F. (1893) Report on the Colorado coal field of Texas: Texas Geol. Survey, 4th Ann. Rept., 1892, p. 355-446.

Dumble, E.T. (1890) Report for the State Geologists for 1889: Texas Geol. Survey, 1st Ann. Rep., 1889, p. XVII-LXXV.

Dunham, R.J. (1962) Classification of carbonate rocks according to depositional texture: Am. Assoc. Petrol. Geol. Memoir 1, p. 108-121.

Eargle, H.E. (1960) Stratigraphy of Pennsylvanian and lower Permian rocks in Brown and Coleman Counties, Texas: U.S. Geological Survey Prof. Paper 345-D.

Erxleben, A.W. (1975) Depositional systems in the Canyon Group (Pennsylvanian System), north-central Texas: Univ. Texas Bur. Econ. Geology Rept. Inv. 82, 75 p.

Fisk, H.N., McFarland E., Kolb, C.R. and Wilbert, L.J. (1954) Sedimentary framework of the modern Mississippi delta: Jour. Sed. Petrology, v. 24, p. 76-99.

Flawn, P.T. (1954) Summary of basement rocks in west-central Texas; in Cambrian Field Trip--Llano Area: San Angelo Geol. Soc. Guidebook, p. 74-77.

Flawn, P.T., Goldstein, H., Jr., King, P.B., and Weaver, C.E. (1961) The Ouachita system: Univ. of Texas Pub. 6120, 401 p.

Geomap (1977) Executive reference map No. 317, central Texas--Fort Worth Basin.

Holmquest, H.J. (1955) Structural development of west-central Texas: Abilene Geological Society Guidebook, p. 19-32.

Hudnall, J.S. and Pirtle, G.W. (1931) Geologic map of Brown County, Texas: Univ. of Texas Bur. of Econ. Geology.

Kier, R.S. (1972) Carboniferous stratigraphy of eastern San Saba County and western Lampasas County, Texas: Unpub. Ph.D. dissertation, Univ. of Texas, 437 p.

Kier, R.S., Brown, L.F. and McBride, E.F. (1980) The Mississippian and Pennsylvanian (Carboniferous) systems in the United States--Texas: Bur. of Econ. Geology, Univ. of Texas Geological Circular 80-14, 45 p.

Laury, R.L. (1962) Geology of the type area, Canyon Group, north-central Texas: Graduate Research Center Jour., v. 30, p. 107-180.

Nickell, C.O. (1938) Stratigraphy of the Canyon and Cisco groups on Colorado River in Brown and Coleman Counties, Texas: Univ. Texas Bull. 3801, p. 91-138.

Plummer, F.B. (1950) The carboniferous rocks of the Llano of central Texas: Univ. of Texas Pub. 4329, 170 p.

Plummer, F.B., and Moore, R.C. (1921) Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, 237 p.

Rainwater, E.H. (1966) The geologic importance of deltas in Deltas and their geologic framework: Houston Geological Society, 15 p.

Rall, R.W. and Rall, E.P. (1958) Pennsylvanian subsurface geology of Sutton and Schleicher Counties, Texas: Am. Assoc. Petrol. Geol. Bull., v. 42, p. 839-870.

Roberts,J.C. (1961) Oil and gas fields of Concho and Menard and neighboring Counties, Texas: South Texas Geol. Soc. Bull., v. 1, p. 10-15.

Roepke, H.H. (1970) Petrology of carbonate units in the Canyon Group (Missourian Series), central Texas: Unpub. Ph.D. dissertation, University of Texas.

Sellards, E.H., Adkins, W.S., and Plummer, F.B. (1932) The geology of Texas, v. 1, Stratigraphy: Univ. Texas Bull. 3232, 1007 p.

Shelton, J.W. (1958) Strawn-Canyon (Pennsylvanian) boundary in north-central Texas: Geol. Soc. America Bull., v. 69, p. 1515-1524.

Tarr, R.S. (1890) A preliminary report on the coal fields of the Colorado River, Texas: Texas Geological Survey, 1st Ann. Rept., p. 199-216.